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Does Product Differentiation Soften Price Reactions to Entry?

Evidence from the Airline Industry

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Abstract

We examine the effects of entry on the pricing of legacy airlines facing a rapidly expanding low-cost newcomer. We estimate the timing and the determinants of responses allowing for asymmetry and product differentiation. We propose a decomposition procedure of time fixed-effects to control for unobserved heterogeneity, accounting for time-varying route-, city-, and carrier-specific unobservables. We find that incumbents do price-respond to actual but not to potential entry. The lack of preemption is due to financial distress, which precluded costly deterrence against a deep-pocketed newcomer. Our model also uncovers product differentiation stemming from more convenient flights.

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1.0 Introduction

This paper estimates the intensity of incumbents' price responses to both potential and actual entry in markets characterised by product differentiation. We aim to uncover not only the timing of price responses to entry, but also the determinants of such reactions, given that the incumbents' products are asymmetrically exposed to competition from the newcomer. By considering the case study of a recently liberalised market — the Brazilian domestic airline industry — we propose an empirical model of price responses by legacy carriers to the entry of a rapidly expanding and successful low-cost carrier (LCC) — Gol Airlines, in the early 2000s.

We estimate a pricing equation for panel data disaggregated at the carrier-route level and investigate the pattern of price responses to the entry of the newcomer. Inspired by Dunn (2008) and Armantier and Richard (2008), we allow for incumbent-specific price responses, thus accounting for heterogeneity across carriers. In particular, we employ measures of product differentiation stemming from peak-hour and nonstop flights. In order to construct these measures, we use the distance-metric approach of Pinkse *et al.* (2002).

The contributions of the paper are twofold. First, it proposes a way to better control for time-varying unobserved heterogeneity across routes and firms in the market, which results in better estimation of the pricing behaviour equation by analysts working with typical panel data. In our empirical analysis we find evidence that this time decomposition (TD) procedure of time fixed-effects is better suited for controlling carrier-specific and market-specific time-varying unobservables. Our TD procedure takes advantage of a usually neglected specificity of airline panels: the fact that routes can be grouped into endpoint cities and therefore the econometrician may control for city-time effects. What we propose is to decompose time fixed-effects into city-time fixed-effects and also into carrier-time fixed-effects, in an attempt to mitigate the omitted-variable bias that every econometrician is subject to when not carefully controlling for unobservables. By performing the TD procedure, analysts are able to control for unobservables such as national- and city-level advertising, overall changes in frequent flier programmes, in-flight service or in the perceived quality, cost shocks, and fleet adjustments at the network and city levels, and potential shifts in travellers' preferences, average income, and propensity to travel after the newcomer's entry and the consequent emergence of new segment of consumers. Our final results reveal that this approach is able to identify the timing and determinants of price reactions in a much more satisfactory way than the traditional approach of only controlling for more aggregate time and route fixed-effects.

The second contribution of the paper is to allow for asymmetry of price responses and examine their determinants. This is important because it sheds light on measures of product differentiation stemming from the higher convenience associated with flight departures at peak times and nonstop flights. We interpret the associated parameter estimates as suggestive that the higher the heterogeneity between the incumbents' and newcomer's products, the softer the price reactions.

Our paper also relates to the literature connecting financial conditions to pricing in the airline industry. Contributions include Borenstein and Rose (1995), which finds that a financially distressed airline lowers prices before filing for bankruptcy protection and therefore suggests that, for these airlines, a financial distress condition may be a more relevant determinant of pricing than a bankruptcy declaration. Along the same lines, Busse (2002) found that highly leveraged firms are more likely to trigger price wars, but does not investigate the effect of bankruptcy protection on pricing behaviour. While Barla and Koo (1999) find that, as a result of the restructuring following Chapter 11, a bankrupt airline manages to reduce its operating costs and is able to lower prices as a consequence, Morrison and Winston (1996) conclude that price wars are less likely in the case of the presence of a bankrupt airline. More recently, Ciliberto and Schenone (2010) also reached the conclusion that airlines lower prices during the formal bankruptcy period but did not find any evidence of lower operating costs, and what is more, prices set by bankrupt airlines are higher in the post-bankruptcy period. In contrast with the literature, we focus on the pricing behaviour of financially distressed airlines facing entry from an LCC in the Brazilian market. A particular feature of this market is that, as opposed to what happens in the US (where bankruptcy protection is part of the existing institutional framework), in the Brazilian case the airline-specific legislation did not allow a firm to declare bankruptcy. In fact, it was only in 2005 (outside our sample period) that airlines were given the possibility to become effectively protected from debt-holders and to engage in restructuring. As a result, we do find significant price responses to actual entry, but not preemptive price reductions by the incumbents. Estimated price responses to actual entry in our preferred specification are usually in the range of 20 to 30 per cent. We offer evidence that the lack of preemptive moves from the part of the incumbents has roots in their financial fragility.

The paper is organised as follows. Section 2 discusses price reactions with a focus on the air transport industry. Section 3 provides an overview of the industry, while Section 4 proposes an empirical model with the TD procedure to control for unobservables. Section 5 describes the data and Section 6 reports the results.

2.0 Price Reactions

The impact of the LCC business model on the performance of the air transport industry has been documented in a number of studies, mostly focusing on post-entry pricing behaviour by incumbent carriers in the US domestic market. Windle and Dresner (1999), Morrison (2001), and, more recently, Hofer *et al.* (2008) are notable examples. Asymmetric responses arise naturally in the airline industry where legacy carriers nowadays commonly face competition from both legacy carriers and LCCs. The latter represent a major challenge to the former not only because of the efficiency differentials due to the low-cost model, but also due to product differentiation. As put by De Villemeur *et al.* (2003) in a study of railways, there exists a strong incentive for both the incumbent and the entrant to differentiate their product in order to recover some profits. It is therefore intuitive that the distance in perceived attributes between the newcomer and the incumbents will condition the intensity of the price competition that follows entry.

Although the issue of asymmetric responses has been suggested by theoretical studies — for example, Kreps and Wilson (1982) — the empirical literature still lags behind the theoretical one. Indeed, empirical studies have usually been concerned with the identification from data of the intensity of responses to actual or potential entry and the timing of such reactions — see, for instance, Thomas (1999) and Goolsbee and Syverson (2008, GS hereafter). An exception is Yamawaki (2002), which examines the question of how firms respond to entry in the US luxury car industry, and reaches the conclusion that reactions are mainly firm-specific, but with groups of players responding in a similar way.

In what follows we propose an estimation strategy accounting for the fact that the incumbents' ability to respond may be specific to the current market position of each carrier and to its relative perceived quality when compared to the newcomer. Intuitively, one may expect incumbents with attributes similar to the newcomer's to have tougher reactions than incumbents with products perceived to be more heterogeneous. By considering product differentiation between incumbents and the newcomer, one may therefore be able to model the differences in the intensity of incumbents' reactions according to the distance between the entrant and each rival in the space of product characteristics.

3.0 The Industry

The Brazilian airline industry was gradually liberalised in the 1990s and has been fully deregulated since 2001. The newly established market environment allowed an unprecedented increase in competition. Moreover, the fact that key inputs such as fuel, leasing, maintenance, and insurance are quoted in US dollars makes the industry quite exposed to exchange rate changes. As a result, the episodes of depreciation of the Brazilian currency against the US dollar in both 1999 and 2002 resulted in incumbent airlines being in a marked state of financial fragility. This is further explored in Lovadine (2009), who finds that airline margins fell after the episode of exchange rate devaluation of 2002. What is more, until 2005, airlines did not have bankruptcy as a last resource for restructuring, as the Brazilian Aeronautic Code of 1986 explicitly forbade formal bankruptcy of an airline in the terms of the Bankruptcy Law of 1945. In short, Brazil did not have a Chapter 11-like legislation and therefore financially distressed airlines were unable to declare bankruptcy, a key factor to take into account throughout our analysis.[1]

Gol Airlines was the first scheduled LCC in Latin America and started operating in the Brazilian domestic market in January 2001. Its first years were marked by classic Southwest Airlines-like operations, with much lower costs than its opponents, aggressive price competition, flights with relatively low length, and absence of in-flight frills. Table 1 presents some of the characteristics of Gol in 2002 and compares it with the major incumbents in the market (Varig, Vasp, and Tam). Gol had unit costs that were significantly lower and a load factor significantly higher than its competitors. As a result, Gol was the only airline with a positive operating margin in the industry.

Gol's entry in the market was an extremely successful event for both the carrier and the regulators, which encouraged its entry from the beginning, aimed at boosting overall

[1]In fact, it was only from 2005 that new bankruptcy protection legislation was enacted. Varig was the first (and only) among the incumbents in the Brazilian air transport industry to engage in restructuring under the new legislation.

Table 1
Gol vs. Incumbents — Brazilian Domestic Market — 2002

Item	*Unit*	*Gol*	*Tam*	*Varig*	*Vasp*
Passenger-kilometres (RPK)	pax × km (billion)	3.22	9.34	10.48	3.39
RPK market share	per cent	0.12	0.35	0.39	0.13
Traffic per employee	pax × km (million)	1.56	1.23	0.75	0.70
Load factor	per cent	0.63	0.53	0.59	0.55
Unit cost	BRL/(pax × km)	0.20	0.33	0.33	0.31
Yield	BRL/(pax × km)	0.21	0.29	0.31	0.27
Operating margin	per cent	0.01	−0.12	−0.05	−0.16
Average stage length	km	792	868	1,017	1,016

Note: BRL means Brazilian currency (Real, in current values).
Source: Department of Civil Aviation's Statistical Yearbook, 2002, vols. I and II.

efficiency. The airline quickly spread its operations all over the Brazilian territory and successfully enhanced the contestability in the market, leading to price reductions which allowed low-income consumers to use airlines for the first time, thus significantly increasing market size. The pace of Gol's expansion was such that it achieved almost 30 per cent of market share in less than four years — more than Southwest after 40 years of operations in the US domestic market — and in 2008 Gol was operating in almost fifty airports and serviced more than 200 routes.

We think that financial fragility of major incumbents in the sample period is a very important issue. Table 1 indicates that, apart from Gol, operating margins were all negative. This situation did not change in 2002 and carriers were in a quasi-bankruptcy situation. Varig actually went bankrupt in 2006 and Vasp ceased to operate in 2004. Another carrier, Transbrasil, had stopped flying in 2001.

4.0 Empirical Strategy

Large panels are increasingly becoming available to airline analysts across the world. Airline datasets are usually disaggregated at the route and carrier levels with increasingly long time series. With such disaggregated data in hands, it is especially important to control for what microeconometricians call 'interindividual heterogeneity'. This interindividual heterogeneity may be related to differences among carriers, routes, and periods which are unobservable to the analyst but may be observed by both passengers and carriers. Cameron and Trivedi (2005) state that ignoring persistent interindividual differences leads to an estimation bias caused by confounding with other factors that are also sources of persistent interindividual differences. This is precisely the classic omitted-variables bias problem. Omitted-variables bias in cross-section estimations is well-known in the literature. Evans and Kessides (1993) and, more recently, Gerardi and Shapiro (2009) exploited the benefits of using fixed-effects to control for price factors that are unobservable to the analyst but not to the firms in the market and reached results that soundly contrasted with previous literature.

Our proposed framework to deal with the omitted-variables problem related to unobserved effects is given by the following pricing equation for incumbent carriers in response to LCC entry threats and actual route entry:

$$\begin{aligned} \ln yield_{ri,t} = \lambda_{ri} + \mu_{i,t} + o_t + d_t + X'_{ri,t}\alpha \\ + \sum_{\tau=-m}^{+j} \delta_\tau (lcc\ flying\ route)_{r,t_e+\tau} \\ + Y_{ri,t}(lcc\ flying\ route)_r \varphi + \varepsilon_{ri,t}, \end{aligned} \quad (1)$$

where ln $yield_{ri,t}$ is the yield (price per passenger-kilometre) for the ith incumbent on the rth route in month t. As in GS we have time dummies to account for potential and actual entry by the LCC. However, GS employed time dummies to control for the periods before and after both entry threats and actual entry episodes. In contrast, here we control only for the time window surrounding actual route entry (*lcc flying route*).[2] We did not control for entry threats strictly *à la* GS, because our sample does not have many cases in which the LCC establishes presence in both endpoints without actually flying the respective route. With this framework we have both actual and potential entry controlled for by time dummies assigned with one for time periods $t_e + \tau$, $\tau = \{-m, \ldots, -1, 0, 1, \ldots, +j\}$, with t_e being the time period in which the LCC actually enters the market.

$X_{ri,t}$ is a vector of cost and market structure shifters of the pricing equation. $Y_{ri,t}$ is a vector of determinants of the intensity of responses, being plugged into equation (1) as an interacted term with a time-invariant dummy version of *lcc flying route*. This interaction ultimately allows us to control for asymmetric price responses that are incumbent-specific in a panel data framework. It was motivated by the work of Windle and Dresner (1999), and permits analysing not only the timing of responses, as in GS, but also the determinants of price responses, given the heterogeneity between the newcomer and the incumbents.

The introduction of terms λ_{ri}, $\mu_{i,t}$, o_t, and d_t is another contribution of this paper. They represent, respectively, specific route-incumbent, incumbent-month, city-of-origin-month, and city-of-destination-month effects. They were introduced to control for unobserved heterogeneity across routes and carriers that are also time-varying and which may be confounded with the included variables. Together, they perform a procedure of decomposition of aggregate time fixed-effects, or simply time decomposition (TD).

The more traditional procedure in airline panels consists of making use of terms λ_{ri} (route-incumbent effects) with aggregate fixed-effects μ_t. More recently, the literature started employing a combination of λ_{ri} with $\mu_{i,t}$ (aggregate carrier-time effects); see GS.[3] We think that even this more recent variation of the usual econometric approach of airline panels fails to account for relevant time-varying effects at the airline and city levels, especially in a rapidly expanding market such as the Brazilian one. In response to entry threats and to actual entry, incumbent airlines may be proactive and therefore promote

[2]All dummies are mutually exclusive.

[3]In the 2005 version of their paper, Goolsbee and Syverson had a more traditional approach of using only aggregate time fixed-effects.

national- and city-level advertising campaigns, enhance frequent flier programmes, restructure networks, fleet assignment, and so on, along with some tactical pricing; moreover, there may be unobserved shocks in carriers' unit costs due to network effects. All these unobserved effects may have different average impacts on different cities and different carriers across time, shifting demand upwards with different intensities. Additionally, the newcomer's entry may have an impact in the price-sensitivity of existing demand segments and may cause new consumers to gain access to the market, making the share of the outside good and the overall market size change. As a consequence, there may be unobserved changes in the average income, propensity to travel, and time- and price-elasticities of the materialised demand. The combination of all factors may result in an upward shift of the incumbent's demand. The overall impact on passengers may also be time-varying and different across routes, being potentially confounded with the estimated price reaction effects.

The usual approach to fixed-effects may therefore lead to inconsistent estimation of pricing equations and to biased inference regarding responses to new entry in airline markets. The reason is that *lcc flying route* dummies are potentially correlated with the aforementioned time-varying unobservables that are carrier- and market-specific. In case of the relevance of such unobservables, the estimated effects of the LCC's presence will be inevitably inconsistent due to omitted-variable bias.

In sum, the TD procedure takes advantage of the panel structure typically found in airline data sets nowadays. The argument is that it is possible to perform conveniently a decomposition of the time-specific fixed-effects usually found in the literature of airline pricing, such as GS and Gerardi and Shapiro (2009). The estimation strategy uses a specificity of panel data for the airline industry, namely the possibility of grouping of markets according to city-of-origin and city-of-destination, in order to perform a decomposition of time-specific fixed-effects into carrier-time and city-time fixed-effects. The former controls for changes in the global strategic variables of firms, such as overall reputation and perceived quality, national-level advertising, overall market positioning in the industry, and so on. The latter is a novelty that allows one to control for many relevant time-varying effects that may be market-specific but related to the endpoint cities, such as city-level advertising, network and fleet management at operational bases, and so on.

5.0 The Data

Our major data source is a set of monthly reports of Brazil's National Civil Aviation Agency, ANAC. More specifically, data collected from ANAC's Average Yield of Monitored Airport-Pairs Reports[4] constituted the original sample with 134 directional airport-pairs over September 2001 and March 2004. These reports contain airline-specific information on fares and number of tickets sold.

We aggregate ANAC's data to the city-pair level. We define a route by its two endpoints and we look only at direct flights on a route. In contrast, GS's sample is constituted not only by entered routes but also by other routes between the airports that Southwest never flies any flights to in the sample period. With this procedure, GS

[4]There is no Brazilian equivalent to the US Department of Transportation's Origin and Destination Survey (Databank DB1B), a 10 per cent random sample of all tickets in domestic markets of that country.

avoided selection biases due to the absence of routes in which an entry threat is real but entry did not occur during the time span of data. Our sample contains routes that Gol either actually entered or threatened to enter by establishing service at the second endpoint but never actually served during the period January 2001 (Gol's startup) to December 2007. We define entry threat as the startup of operations in a given airport/city. The degree of credibility of the entry threat is increased when the newcomer establishes presence in the second endpoint which, as GS emphasise, is a well-known predictor of future route entry.[5]

It is important to emphasise that we do not have a sample selection procedure strictly *à la* GS. That is, we do not exclude routes in which entry has already occurred and do not exclude routes in which Gol establishes the second endpoint airport simultaneously with actually flying the route. Had we not done so, we would have ended up with too small a sample, as Gol started to operate almost simultaneously in a number of markets. Thus, as the Brazilian airline market is not as big as the US market, we have fewer routes and therefore fewer entry episodes. Discarding already-entered routes would mean disregarding many important routes in which responses to actual entry were occurring within the sample period. We believe this would underestimate the effects of responses to actual entry stemming from competition in the densest routes of the country — and consequently the most strategic routes from the point of view of incumbents. We also believe that including those routes does not have a great impact in the estimation of potential entry effects, since those routes are used only to help in the estimation of the responses to actual entry. Also, we believe that if routes could be classified into sorts of entry — for example, routes in which the second endpoint airport presence was installed simultaneously with actual entry or routes in which the second endpoint was installed before actual entry — then simple route fixed-effects could control for their systematic differences in the sample. We therefore believe that no bias in the estimation of price responses to both actual and potential entry would emerge, mainly because we have enough controls for route-level idiosyncrasies.

We focus on the three major incumbents at the time: Tam, Varig, and Vasp. These incumbents accounted for 98 per cent of all non-Gol passenger-kilometres in the period. The final sample is therefore a subset of the sample originally collected from the ANAC, consisting of a panel of 6,421 observations in which the unit of observation is an airline-directional route-month triple. The final sample contains information on eighty-five routes, twenty cities (twenty-three airports) and 31 months. Apart from 227 route-carrier fixed-effects, our TD procedure has controls for 93 carrier-month fixed-effects and additionally 465 city-month ones. We therefore have 785 fixed-effects controls, which represent 12 per cent of the sample size. We therefore do not have problems with the degrees of freedom when conducting the TD procedure. Moreover, the very nature of our panel makes us confident that the total number of observations increases at a faster rate than the number of airports, cities, routes, carriers, and time periods. We then believe that standard consistency arguments hold in our estimation.

The dependent variable is ln $yield_{ri,t}$, the natural logarithm of average real yield (average fare per passenger-kilometre) of the ith incumbent on the rth route at month t.

[5] See also Boguslaski *et al*. (2004).

Table 2
Evolution of Gol's Presence in the Sample

	Sample		
LCC presence	*Begin Sep-01*	*Midpoint Dec-02*	*End Mar-04*
Routes served	54	72	80
% Sample routes	63	84	93
Cities served	11	17	18
% Sample cities	55	85	90

Yields are expressed in local currency (BRL — Brazilian Real) and represent not a sample but the population of all tickets sold in the market. Yields were deflated by the IPCA, the consumer price index of IBGE, the Brazilian Statistics Office.

We gathered information on potential and actual entry variables from HOTRAN reports (2001–4), a flight data system kept by the regulator that gathers information of all scheduled flights within the country. Data is disaggregated by airline and flight code. Therefore, our data on flight frequency and number of available seats consists of monthly information for scheduled flights, being collected at the mid-point day of each month. Table 2 presents the evolution of Gol's entries within the sample.

Our data comprises a 31-month fixed window common to all routes in calendar time. Starting in calendar time, we create city-month and carrier-month dummies (TD), as well as the determinants of price reactions, all of which are variables allowing us to account for how price reactions vary over calendar time across different routes and cities. Finally, we synchronise the data according to entry episodes to define the potential and actual entry dummies. One could well argue that although we have a fixed window concerning data availability, we actually do have a floating window surrounding entry episodes for route classification and timing setup. As we allow the intensity of price reactions to vary across time, we have to make reference to the historical entry time — irrespective of the available sample period — as the reference for accounting for the entry episodes. In the end, it is as if we had a floating window but have some missing data in the extremes of the series for some routes.

For the final empirical specification (equation (1)), we need to construct the vectors $X_{ri,t}$, corresponding to the cost and market structure shifters, and $Y_{ri,t}$, the determinants of responses. We use the following variables. To construct $X_{ri,t}$, first we use *Proportion of nonstop seats*, the percentage of nonstop seats on the rth city-pair at month t — the number of nonstop seats of airline i over the number of total seats on the route.[6] It is a

[6]By 'total seats' we mean all seats on direct flights on the route. Flight connections are therefore not considered. We included flights with up to two intermediate stops between two given endpoint cities. We attempted using the variable *Proportion of nonstop seats* without interactions, but it proved to be insignificant in all specifications. Hub and spoke is not as common in Brazil as in the US. Many airlines still put in practice point-to-point routes with many intermediate stops. We believe that this variable without interactions was not significant because the effect of higher quality is counterbalanced by the effect of lower costs stemming from more direct flights. Final results confirmed this.

proxy for level of service and convenience of the airlines (Dunn, 2008), but also for the cost-efficiency permitted by nonstop flights. In order to check the performance of this variable in different subsets of the sample, we employ interactions of the regressor with dummies of short-haul routes (that is, routes with less than 775 km, the median flight length) and medium-/long-haul routes (that is, routes with more than 775 km). Second, we use ln *Distance over Average Flight Length*, a term proposed by Brander and Zhang (1990) to convert system-wide-level unit costs to route-specific costs.[7] In their base case, it was assigned with a coefficient equal to -0.50.[8] By interacting a route-level term (*Distance*) with a network-level term (*Average Flight Length*), we have a non-linear function that accounts for cost tapering effects — that is, the fact that the total cost per passenger-kilometre usually decreases as the flight length grows. Distance is the great-circle distance between endpoints and average flight length is the average distance travelled by the carrier's aircraft, weighted by total passengers flown in the flight leg, obtained from ANAC's Monthly Operations Report. Both are expressed in kilometres. Third, we use *Fuel Consumption*, the average litres of aviation fuel per kilometre for the aircraft assigned to the route, a cost shifter obtained from ANAC's Monthly Operations and HOTRAN reports. Finally, *Route presence of 2 and 3 incumbents*, a set of dummy variables for the cases in which there are operations on the route by two or three major legacy incumbents, respectively. The base case is the set of routes with only one incumbent.

To construct $Y_{ri,t}$, we employed distance-metric proxies to control for potential asymmetries of incumbents when price-responding to entry. The use of distance-metric variables is proposed by Pinkse *et al.* (2002) for demand-system estimation. With this approach, brands of a differentiated product compete along their intrinsic characteristics and *substitutability between brands depends on distance measures* (Slade, 2004). In the context of this study, the metrics were used as an indicator of the degree of heterogeneity between incumbents and the newcomer with respect to their characteristics. In other words, we assessed how price reactions to LCC's entry varied due to product differentiation by using the distance-metric framework. The newcomer and the incumbents' differentiated products were therefore analysed in terms of their distance in a space of characteristics which may intensify or soften price reactions to entry.

We employ a modified version of the framework of Pinkse and Slade (2004) and Slade (2004) to develop a distance metric between two given brands i and j in the space of characteristics:

$$\textit{Distance metric}\,(x) = d\left(x_i,\, x_j\right) = -\frac{3}{2}\left[\frac{1}{1 + 2abs\left(x_i - x_j\right)} - 1\right], \tag{2}$$

where $d(x_i, x_j)$ is a distance-metric function for the characteristic x of brand i and brand j. This specification provides a measure of distance rather than closeness. Therefore, we have that the higher $d(x_i, x_j)$, the more distant are the two given brands with respect to

[7]Note that this variable is carrier-route-time specific. Although distance is a route-specific metric, average flight length is carrier-time specific. The interaction of these variables results in a new variable — distance over flight length — which is not perfectly collinear with route-carrier fixed-effects.
[8]Brander and Zhang (1990, p. 575).

Table 3
Descriptive Statistics

Variable	*Mean*	*Std. Dev.*	*Min*	*Max*
Yield	0.687	0.326	0.123	3.402
Distance metric (nonstop)	0.444	0.331	0.000	1.000
Distance metric (peak hour)	0.489	0.326	0.000	1.000
Proportion of nonstop seats × short-haul	0.897	0.245	0.000	1.000
Proportion of nonstop seats × long-haul	0.640	0.378	0.000	1.000
Distance over average flight length	0.781	0.571	0.046	3.120
Fuel consumption	5.514	0.975	0.390	17.781
Route presence of 2 incumbents	0.303	0.460	0.000	1.000
Route presence of 3 incumbents	0.663	0.473	0.000	1.000

characteristic x. We expect that the higher $d(x_i, x_j)$, the softer the responses to entry. Also, if x is a share and therefore lies within the interval [0, 1] then $d(x_i, x_j)$ conveniently lies between 0 and 1.

The variables used in the empirical specification of $Y_{ri,t}$ were the following. First, *Distance metric* (*nonstop*), a distance metric for the relative share of flight frequencies of airlines with respect to nonstop flights — see details of the variable *Proportion of nonstop seats*. Second, *Distance metric* (*peak hour*), a distance metric for the relative share of flight frequencies of airlines during peak hours. For this calculation, we define a peak time period considering all flights with departure between 5 a.m. and 10 a.m. (morning peak) and 4.30 p.m. to 10 p.m. (evening peak) on weekdays (obtained from HOTRAN). Both *Distance metric* (*nonstop*) and *Distance metric* (*peak hour*) were conceived to be aggregate measures that control for similar effects of the more disaggregate, flight-specific metrics of Borenstein and Netz (1999).

Table 3 above presents some descriptive statistics of the main variables employed in the empirical model.

6.0 Results

We now report the estimation results comparing our TD procedure as in equation (1) with the specification without TD, but with carrier-time fixed-effects as in GS. All regressions are weighted by the number of total passengers, with standard errors clustered at the route level to account for correlation across time and across carriers on the same route.

Table 4 presents the estimation results. The first two columns report estimates with only time dummies of price responses (Only Timing specifications). The last two columns present results of the more complete specifications in which the time dummies are jointly estimated with the proxies for determinants of responses (Timing + Determinants specifications) — that is, with the interaction between the actual entry dummies and the distance-metric proxies.

We report results for the specification in equation (1) without TD (columns (1) and (3)) and with TD (columns (2) and (4)). We performed F-tests of exclusion restrictions and rejected at 1 per cent level of significance the joint null hypothesis of no significance of the additional fixed-effects of the TD.

Table 4
Estimation Results (Dependent Variable: ln yield)

Variables	Only Timing (1) w/o TD	(2) with TD	Timing + Determinants (3) w/o TD	(4) with TD
Timing: potential entry				
>6 months before lcc flying route	⟨base case⟩	⟨base case⟩	⟨base case⟩	⟨base case⟩
6 months before lcc flying route	0.018	0.000	0.016	0.004
5 months before lcc flying route	0.007	−0.003	0.005	0.001
4 months before lcc flying route	−0.016	−0.066**	−0.020	−0.065**
3 months before lcc flying route	0.005	−0.029	−0.004	−0.028
2 months before lcc flying route	0.013	−0.008	0.002	−0.012
1 month before lcc flying route	0.042	−0.041	0.031	−0.044
Timing: actual entry				
lcc flying route: startup month	0.014	−0.128***	−0.053*	−0.191***
1 month after lcc flying route	−0.046	−0.164***	−0.112***	−0.226***
2 months after lcc flying route	−0.051	−0.198***	−0.124***	−0.265***
3 months after lcc flying route	−0.063**	−0.236***	−0.138***	−0.305***
4 months after lcc flying route	−0.138***	−0.264***	−0.211***	−0.334***
5 months after lcc flying route	−0.256**	−0.295***	−0.326***	−0.364***
6 months after lcc flying route	−0.139***	−0.265***	−0.210***	−0.335***
>6 months after lcc flying route	−0.128***	−0.282***	−0.210***	−0.359***
Determinants of reactions				
lcc flying route × distance metric (nonstop)			0.076*	0.063*
lcc flying route × distance metric (peak hour)			0.047	0.064**
Costs and structure controls				
Proportion of nonstop seats × short-haul	0.101	0.128**	0.127*	0.150***
Proportion of nonstop seats × long-haul	−0.064*	−0.039	−0.065	−0.039
ln (Distance over average flight length)	−0.068***	−0.215***	−0.038	−0.200***
ln (Fuel consumption)	0.104***	0.083***	0.096***	0.079***
Route presence of 2 incumbents	0.034	−0.061	0.043	−0.064
Route presence of 3 incumbents	−0.055	−0.186***	−0.036	−0.179**
Fixed-effects				
Route-carrier fixed-effects	Yes	Yes	Yes	Yes
Carrier-time fixed-effects	Yes	Yes	Yes	Yes
City-time fixed-effecs	No	Yes	No	Yes
Adjusted *R*-squared	0.838	0.873	0.839	0.874
Root MSE	0.150	0.133	0.149	0.132

Note: ***, **, and * denote, respectively, significance at 1 per cent, 5 per cent and 10 per cent. Estimated fixed-effects coefficients omitted. Regressions are weighted by the number of total passengers, with standard errors clustered by route to account for correlation across time and across carriers on the same route.

In our preferred specifications (columns (2) and (4)) we did not find support for the view according to which airlines preemptively price-respond to imminent entry. In fact, with these models, the set of time dummy variables *X months before lcc flying route* were not statistically significant in general.[9] We had only *4 months before lcc flying route* being significant at the 5 per cent level, probably meaning that we had transitory price movements at the startup of sales by the newcomer, some months prior to the actual startup of its flight operations.

When it comes to reactions to actual entry, we stress two main findings. First, although all specifications have many statistically significant price reductions after the LCC's startup month on the route, for those specifications without TD the estimated price reactions are usually milder. The magnitude of these reactions is such that it is not possible to classify them as price wars employing the 20 per cent reduction threshold of Morrison and Whinston (1996). In other words, the more usual approach suggests accommodation by the incumbents, in stark contrast with the TD estimates. This suggests the existence of an omitted-variable bias in the sample. We believe our city-month effects procedure is able to control for both overall advertising and exogenous socio-economic effects at the city level. We emphasise advertising because this is precisely the omitted variable that may be correlated with the entry dummies and therefore may cause omitted-variables bias. Markets with higher prices tend to be more business-traffic-related and therefore are the ones with consumers who have a higher willingness. In these markets, the advertising levels are potentially higher. We therefore hold that this omitted-variable bias is positive, as advertising is positively correlated with both prices and entry. Hence, without controlling for city-month effects, we would have smoother estimated price reactions. This is precisely what our results indicate.

Second, the baseline specification in column (1) failed to uncover any significant price reactions in the first three months after entry. We argue that both results are counter-intuitive for two reasons:

(i) the media frequently announced price wars episodes in the first years after Gol's entry in the domestic market;[10] and
(ii) even financially distressed legacy carriers such as Varig and Vasp announced discounts in the period, clearly signalling that they would not adopt a wait-and-see approach before price-responding.

Once again, we think that the results corroborate our view that not only is pricing correlated with relevant route-, city-, and carrier-specific unobserved time-varying effects, but also failure to account for these factors leads to inconsistent estimation of the coefficients of the pricing equation due to omitted-variable bias. This correlation of yields with unobservables may undermine the ability of the researcher to identify the impacts of the entrant's route presence.

As for the determinants of responses, we hold that without TD, only the proxy for nonstop flights distance-metric is statistically significant. In contrast, the TD approach of column (4) reveals a significant coefficient also for the peak-hour flights distance-metric. This is suggestive that in the investigated markets, higher convenience is perceived as

[9]We experimented with a dummy to control for differences in price responses when the LCC operated both endpoints (no flights) and when it operated only one endpoint of the route. This dummy was not significant in any of the specifications.
[10]See *New York Times*, 22 August 2002, '*In Brazil, Gol Succeeds in the No-Frills Path*'.

higher quality when associated not only with lower flight duration but also with lower scheduled delay — that is, flight times closer to desired times. We think that this may represent a contribution with respect to the findings of Dunn (2008), which distinguishes high quality from low quality based only on nonstop versus one-stop service availability. Our results suggest that peak-hour availability may also enhance perceived quality of service in the airline industry.

Our results regarding cost-side variables are as follows. With respect to the proportion of nonstop seats, we believe that the positive association on short-haul routes — the estimated effect of *Proportion of nonstop seats* $\times$ *short-haul* is positive and significant — is related to the effect of higher perceived quality stemming from a higher proportion of nonstop flights. This is in accordance with Dunn (2008) and Evans and Kessides (1993). The novelty here is that this effect is not significant on long-haul routes (*Proportion of nonstop seats* $\times$ *long-haul*). We believe that on those routes the quality effect is fully compensated by the effect of lower costs associated with nonstop flights. Additionally, both the relative distance variable and the fuel consumption shifter proved to have a significant impact on prices through costs.

Finally, the analysis of market structure reports significant results related to the number of incumbents in the market only when TD is performed: the difference between estimates suggests that the number of incumbents is correlated with the error term and that the TD procedure helps with the elimination of this correlation.

In sum, by employing TD it was possible to uncover statistically significant price responses to actual entry and their determinants in a more reasonable way than the commoner approach. As discussed above, we interpret this finding as evidence that the more usual approach fails to account for relevant time-varying effects at the route, airline, and city levels. For instance, in response to entry, airlines could have conceded bonus on their frequent flier programmes, enhanced their in-flight service, increased their advertising expenditure, and restructured their networks along with some tactical pricing. These effects might have had different impacts on different cities and different carriers across time, shifting demand either inwards or outwards. As a consequence, the overall impact on passengers may not only be time-varying but also different across routes. By controlling for TD we were in a position of revealing more sensible and significant price responses to Gol's entry.

7.0 Conclusions

This paper investigates the impacts of entry on prices of incumbents in differentiated product markets by studying the recently liberalised Brazilian airline market. Our estimation strategy uses a specificity of panel data for airline markets — the grouping of markets according to city-of-origin and city-of-destination and the resulting generation of city dummies — to perform a decomposition of time-specific fixed-effects into city-time and carrier-time fixed-effects. This approach was conceived in order to deal with unobserved heterogeneity across routes, carrier, and time in the pricing equation. The time-decomposition approach suggests that previous studies in the literature may lack robustness, a subject that deserves further investigation.

We also allow for asymmetric price responses due to evidence of product differentiation in airline markets. To do so we employ distance-metric proxies constructed in the spirit of Pinkse *et al.* (2002). We find evidence that product differentiation associated with peak-hour flights — along with nonstop flights — significantly softened the intensity of reactions. We believe that peak-hour seat availability is a major source of horizontal product differentiation, as time-sensitive passengers are able to find flight times closer to their desired times. As a result, our estimates show evidence of asymmetries in the price responses among incumbents within the sample, which is certainly representative of a relevant source of competitive advantage in the airline industry. As higher peak-hour seat availability is usually associated with dominance of slots at congested airports, we therefore have strong evidence that the regulation of airport access by different types of airlines — majors, low-cost carriers, smaller regional carriers, and newcomers — is a relevant issue to be dealt with by policy makers concerned with improving social welfare.

Our results show that incumbents do price-respond to actual entry but not to (imminent) potential entry. We believe that the fragile financial conditions of incumbents in the market under study may be the cause of such lack of preemptive behaviour. This may be indicative that strategic behaviour such as reactions to potential entry is impacted by the institutional setting as much as the overall economic and financial conditions prevailing in the market: simply put, incumbents tend not to react preemptively when their own survival is at stake.

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